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ABSTRACT

This booklet gives brief outlines by career field, of each of 20 professional occupations in the energy field. Each outline includes the challenges faced by the particular energy professional, the educational standards for entry into the profession, the subject areas of concentration in high school, the nature of college training needed, and adult education opportunities for those considering a career change into the particular profession. Sources of information on the career field are listed for each career. (RE)

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Professional Energy Careers

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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United States Department of Energy

Professional Energy Careers

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United States Department of Energy
Office of Public Affairs
Washington, DC 20585
May 1979

Introduction

The present energy problem revolves around the fact that gas and oil, which provide three-fourths of our energy needs, are running out, and our whole society is geared to these very convenient forms of energy. The transition to other forms of energy will take time and a great deal of work and money. Our entire energy system – production, transportation, and consumption – will have to be modified or replaced within the lifetimes of people now in high school and college.

One consequence of this will be a shift in the national work force and the possible creation of thousands of new jobs. A society cannot change from one kind of fuel to another without large-scale dislocations and in this there is opportunity. New skills will be required to design and operate the new energy machinery and minimize its effect on the environment.

The transition will take decades and the direction of the changes is not yet certain. We cannot say, "Get into this field or that field", with confidence.

The transition will also not be a complete one. Electricity will probably continue to be

the mainstay of the home, and we shall doubtless retain many personal vehicles powered by a liquid fuel. Many energy jobs will be unaltered; others will change but little, and employee retraining will be possible. Indeed, those already in the energy field should read the handwriting on the wall and begin re-educating themselves. One of the big demands will be for geoscientists and geoengineers and those traditionally concerned with earth sciences and the recovery and processing of gas and oil. Many more scientists and experts will be needed in the coal, nuclear, solar, and geothermal fields. But the "new look" in energy will also create a greatly expanded demand for professionals, such as lawyers, architects, urban planners, and environmental engineers, who have heretofore not been involved deeply in energy matters.

This booklet gives a brief outline of the professional careers in the energy field. For a list of general interest and educational publications write to: DOE-TIC, P.O. Box 62, Oak Ridge, TN 37830, for a copy of *Selected Department of Energy Publications*.

Architect/Architect Engineer. Regardless of the ultimate energy solution we will have to construct new facilities to process the new fuels, to collect sunlight, and to rebuild our energy-generating capacity. Some will be of enormous size, rivaling the biggest oil refineries; others will be novel designs in unusual environments, such as the proposed floating wind-generator platforms at sea. In addition homes will be modified or rebuilt to conserve energy and use the new fuels being developed. Architects, therefore, will face many challenges in the future as energy generation and consumption change.

The minimum education required for an architect is a B.S. from a school accredited by the National Architecture Accrediting Board. (Some schools offer a 2-year program leading to an Architectural Technician Certificate.) Most schools of architecture have 5-year programs. Six-year programs leading to a Master of Architecture degree are popular and provide a wider range of options. The states generally insist upon 3 years of experience via an internship in an architect's office before

taking State Professional Registration examinations.

High School Emphasis. Mathematics, the physical sciences, the social sciences, English, and art.

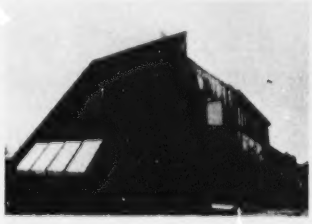
College Training. An architecture major studies mathematics, mechanical engineering, geology, economics, law, English, and, of course, art and design. A list of accredited schools may be obtained from the American Institute of Architects. (See address below.)

Adult Education. Night and/or part-time education in architecture is difficult to arrange. Most schools of architecture are full-time institutions. Switching to a career in architecture is therefore difficult.

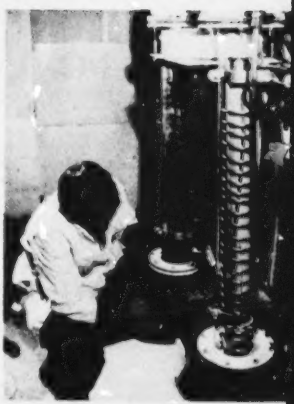
Sources of Information

American Institute of Architects, 1735 New York Avenue, N.W., Washington, DC 20006. Booklets: *Getting into Architecture* and *The New Architect*.

Architecture Careers Today, Robert Piper, National Textbook Company, 8259 Niles Center Road, Skokie, IL 60076. $5.50 (hardback); $3.95 (paperback).



Chemist/Chemical Engineer. Over 90% of America's energy comes from chemical fuels. Chemists and chemical engineers are involved in every step of fuel manufacturing and use from source to the disposal of wastes in the environment. Even nuclear power depends heavily upon chemists and chemical engineering for fuel manufacturing, the reprocessing of spent fuel, and the disposal of wastes. Since the quality of the environment is a function of its chemistry, there are also many opportunities for chemists here. No matter what direction future energy research and development takes, chemists and chemical engineers will find important jobs.



High School Emphasis. Mathematics, chemistry, physics, English, and other physcial sciences.

College Training. A B.S. degree is a necessity for all chemists and chemical engineers. Advanced degrees are advisable for those in-

terested in research and development. Courses in geology, the environmental sciences, automation, and computer science are desirable.

Adult Education. Courses in chemistry and chemical engineering are often available in night schools and for part-time students. It is even easier to redirect a career to the energy field through courses in automation, environmental science, and computer science on a part-time basis; these are common subjects in adult education programs.

Sources of Information

Engineers' Council for Professional Development, 345 East 47th Street, New York, NY 10017. List of accredited schools with chemical engineering curricula.

American Chemical Society, 1155 16th Street, N.W., Washington, DC 20036. Booklets: *Careers in Chemistry: Questions and Answers* and *Chemistry and Your Career.*

Civil Engineer/Construction Engineer. The generation and transportation of fuel and electrical energy could not be accomplished without thousands of refineries, generating plants, and mining facilities connected by a continental web of roads, railroads, and power transmission lines. Civil engineers and construction engineers design and supervise the building of these structures. Within these general categories, there are such specializations as surveyor, power engineer, highway engineer, structural engineer, and so on. The energy field is so wide in scope that all these specialties are represented.

A B.S. degree from an accredited school is usually sufficient for a professional civil or construction engineer. Because public safety is involved in most assignments, all states insist that Professional Engineer licenses be obtained.

High School Emphasis. The physical sciences, mathematics, and English. Summer work on a construction site provides superb experience.

College Training. In addition to the regular civil engineering curriculum, courses are desirable in mechanical engineering, environmental engineering, law, geology, and the computer sciences.

Adult Education. Civil engineering is more difficult for older people to enter because of the rigorous outdoor work it entails. In addition, few courses are offered for the night or part-time student.

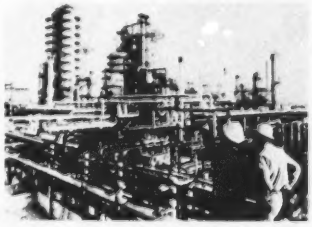
Sources of Information

Engineers' Council for Professional Development, 345 East 47th Street, New York, NY 10017. List of accredited schools.

American Society of Civil Engineers, 345 East 47th Street, New York, NY 10017. Booklet: *Is Civil Engineering for You?*

The New World of Construction Engineering, George Sullivan, Dodd, Mead and Company, New York, 1968, $3.25.

A History of Civil Engineering, Hans Straub, MIT Press, Cambridge, MA, 1964, out of print.



Computer Scientist/Programmer. Computers have become as essential in energy as they have in most business and technical activities. The list of energy applications is very long, but a few examples are:

Analysis of geophysical data and map preparation.

Control of electrical power distribution.

Control of petroleum refineries.

Analysis of oil field reservoirs.

Analysis of nuclear reactor designs.

Control of machine tools in automobile engine manufacture.

Business-oriented computations.

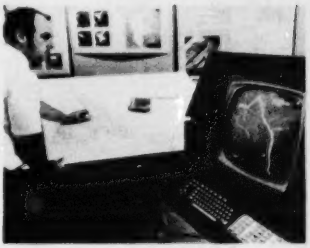
The heavy use of computers in industrial control is a characteristic wherever large volumes of materials are processed or where automation is practical. It is safe to say that computers are employed at almost every point in the energy flow chart except in remote field operations and by the individual consumer of energy. Furthermore, like most big concerns, energy companies have thoroughly computerized their business operations.

Most colleges and universities have degree programs leading to B.S. and advanced degrees. Jobs may be found at all levels of education, even below the B.S. In fact, most technical institutes and 2-year colleges offer certificates and associate degrees in some phase of computer science.

High School Emphasis. Mathematics, the physical sciences, English, and in some larger high schools, computer programming.

College Training. Mathematics, of course, is of first importance, but a good understanding of physical laws is essential. The best-paying jobs require advanced degrees. Some programmer jobs are available for applicants without a B.S. degree, but a certificate from a computer programming school is generally required.

Adult Education. Night courses and part-time curricula are easy to find in computer science, particularly below the B.S. level. Many engineers and scientists, regardless of their specialties, take a course or two in computer science because computers are important in all technical work. It is relatively easy to move into computer science from another discipline or even from subprofessional work.



Sources of Information

Data Processing Management Association, 505 Busse Highway, Park Ridge, IL 60068.

Association for Computing Machinery, Inc., 1133 Avenue of the Americas, New York, NY 10036.

American Federation of Information Processing Societies, 210 Summit Avenue, Montvale, NJ 07645.

Electronic Data Processing, Martin Nussbaum, National Textbook Company, 8259 Niles Center Road, Skokie, IL 60076. 1971, $4.95.

Economist/Accountant.

Individuals trained in economics and business finance are employed at all levels of the energy/environment field, from boards of directors to cost analysts and accountants. Basically, there is little difference between the energy field and other businesses with substantial foreign interests and a significant degree of Government regulation. The political nature of many policy decisions by the United States and foreign governments is a complicating factor that is very familiar to economists in say, the computer industry. Therefore, the work done by economists, financial analysts, accountants, statisticians, etc., is much like that done by their counterparts in other segments of the economy.

Virtually all colleges and universities have courses leading to degrees in economics and accounting. Advanced degrees are desirable, particularly in economics, but work experience and intimate knowledge of a company are perhaps more useful. Many subprofessional openings are usually available in finance and an in-

dividual can move ahead through part-time education.

High School Emphasis. Mathematics, business, social science, English, and history.

College Training. Economics, computer science, statistics, business management, history, and English. In a field as highly technical as energy, economists should take some basic science courses. Summer jobs in accounting can provide invaluable experience.

Adult Education. Many correspondence and night schools offer courses in finance and accounting, as do most 2-year colleges. Many part-time students gain work experience while learning computer technology and advanced economics analysis and accounting techniques.

Sources of Information

American Economic Association, 1313 21st Avenue, Nashville, TN 37212.

Financial Executives Institute, 50 West 44th Street, New York, NY 10036.

National Association of Accountants, 505 Park Avenue, New York, NY 10022.

United Business Schools Association, 1730 M Street, N.W., Washington, DC 20036.

Electrical Engineer. Since about one-fourth of the Nation's energy is being converted into electricity, which is the most convenient form of energy, electrical engineers are vital to our energy future. Hundreds of new fossil fuel and nuclear generating plants are scheduled for construction during the next 20 years. Electrical engineers can look forward to employment in these more conventional areas or they can help in the search for alternate ways of generating electricity from the sun, the wind, ocean thermal differences, and other unconventional sources. Challenges also exist in electric power transmission, particularly in underground superconducting cables. In homes and factories, considerable energy can be saved by redesigning lighting and electrical machinery for more efficient operation — a trend that will be enforced by the rising cost of electricity.

At least a B.S. degree is required in electrical engineering, and advanced degrees are preferred. States generally insist that electrical engineers working on a project involving public

safety (usually the case with a power project) be licensed.

High School Emphasis. Mathematics, the physical sciences, and English.

College Training. Besides a degree in electrical engineering, some employers will also accept degrees in physics or mechanical engineering. In addition, graduates must be familiar with computer usage.

Adult Education. Courses in electrical engineering are frequently offered in the evening, and it is possible to get a degree in electrical engineering without full-time attendance at college. Trade and technical schools offer many practical courses in electricity that can be stepping stones to electrical engineering.

Sources of Information

Institute of Electrical and Electronics Engineering, 345 East 47th Street, New York, NY 10017. Career pamphlets.

Institute for Research, 610 South Federal Street, Chicago, IL 60605. Booklet: *Electrical Engineering as a Career.*

Environmental Engineer.

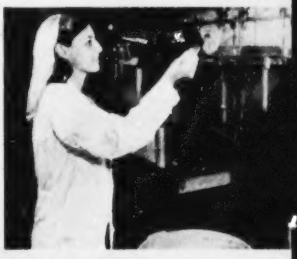
Environmental engineering has a three-fold objective:

1. To protect people from the environment.
2. To protect the environment from people.
3. To clean up the environment.

The generation and use of power can seriously affect the environment (and consequently people) through gaseous emissions, despoiling through mining, the release of heat, the disposal of radioactive wastes, oil spills, and the like. The use and misuse of energy is probably the greatest single threat to the environment. The environmental engineer thus has his or her work cut out.

Many college students have shown their concern for the environment by ignoring other fields of engineering in favor of environmental engineering, and therefore although good people are still needed, the field is no longer wide open.

Over 200 colleges now offer B.S. degrees in the subject. Many colleges offer curricula in such closely allied fields as biology, biochemistry, ecology, oceanography, industrial hygiene, and safety engineering. The B.S. degree, however, is not really sufficient anymore. Those serious about becoming environmental engineers should plan on at least an M.S. Environmental engineering is intimately connected with public health and, for this reason, a state license must be obtained almost everywhere.



High School Emphasis. The physical sciences, biology, English, and mathematics.

College Training. Environmental engineers must understand many facets of science: biology, physics, chemistry, geophysics, computer sciences, environmental law, and instrumentation.

Adult Education. Environmental engineering is a composite science; that is, degree holders in physics, chemistry, meteorology, and similar subjects can often take enough night or part-time courses to obtain degrees in environmental engineering. As noted above, however, advanced degrees are the rule these days.

Sources of Information

Association of Environmental Engineering Professors. Attn. Martin P. Wanielistz, College of Engineering, Florida Technological University, Orlando, FL 32816. Booklet: *So You Want to Be an Environmental Engineer.*

Institute of Environmental Sciences, 940 East Northwest Highway, Mt. Prospect, IL 60056. Publication list.

National Association for Environmental Education, 5940 Southwest 73rd Street, Miami, FL 33143. Publication list, curricula guides.

Sierra Club Foundation, 220 Bush Street, San Francisco, CA 94104. Career reprints.

Information Office, Tennessee Valley Authority, Knoxville, TN 37902. Directory of its environmental programs.

Environmental Protection Agency, Washington, DC 20460. Booklet: *Career Choices.*

Career Opportunities: Ecology, Conservation and Environmental Control, Doubleday and Company, Inc., New York, 1971, $6.95.

Careers in Conservation, Christopher Benson, Lerner Publications Company, Minneapolis, MN, 1974, $3.95.

Careers in Environmental Protection, Reed Millard, Julian Messner, New York, 1974, $6.25.

Jobs That Save Our Environment, Melvin Berger, Lothrop, Lee and Shepard, New York, 1973, $5.50.

Looking Forward to a Career: Environment, Robert L. Herbst, Dillon Press, Minneapolis, MN, 1974, $4.95.

Environmental Careers, Odom Fanning, National Textbook Company, 8259 Niles Center Road, Skokie, IL 60076, 1974, $6.50 (hardback); $4.75 (paperback).

World Directory of Environmental Education Programs, Philip W. Quigg, R. R. Bowker Company, New York, 1975, $14.95.

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Geologist. Geologists often begin their careers on field crews, sometimes in foreign lands. Field parties hunting for new fuel sources make maps, collect samples, conduct test drilling, and employ seismometers, magnetometers, and other geophysical instruments. In the field, hours are frequently long and the weather inclement. But many geologists find this kind of work exciting. Geologists also work at desk and laboratory jobs analyzing the data collected by field crews. Here, the working conditions are more conventional. The analysis and interpretation of geological and geophysical data involve chemistry, radioactive dating, fossil identification, and the study of drill core samples and logs from test wells. Computers are widely employed in map making and data analysis.

The job opportunities are best for geologists with advanced degrees. Indeed, the B.S. is no longer considered adequate for most professional work. Approximately half of all professional geologists hold advanced degrees, and this fraction is increasing. Research positions invariably require a Ph.D.

High School Emphasis. Mathematics, the physical sciences, and English.

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College Training. Curricula vary widely. The student should acquire proficiency in computer use and geophysical instrumentation. Courses in management, economics, and the environmental sciences are also desirable.

Adult Education. Geology courses are rare in adult education curricula. Refresher courses or retraining usually involves going back to college on a regular basis. It is time-consuming and expensive to move into geology from another discipline because of the general requirement for advanced degrees.

Sources of Information

American Geological Institute, 5205 Leesburg Pike, Falls Church, VA 22041. *Directory of Geoscience Departments,* $8.00; *Geology, Science and Profession,* $1.00.

U. S. Geological Survey, Information Office, Washington, DC 20244. Booklet: *Careers in the United States Department of the Interior.*

Your Future in Geology, Joseph L. Weitz, Richards Rosen Press, Inc., New York, 1970, $4.00.

Geology and Geological Engineering, A. K. Snelgrove, National Textbook Company, 8259 Niles Center Road, Skokie, IL 60076, 1970, $1.95 (hardback); $0.95 (paperback).

Geophysicist. In contrast to the geologist, who infers the presence of oil and other minerals from surface rocks and drilling samples, the geophysicist looks for telltale signs in the strengths and directions of the earth's magnetic and gravitational fields. He also studies the seismic records obtained from small test explosions. Other geophysical methods include electrical, radioactive, and geochemical prospecting. Through the preparation of subsurface maps based upon these manifestations, plus geological data, the geophysicist recommends the drilling of test wells and the sinking of shafts in specific areas. Thus, he does not discover oil and other minerals directly but rather pinpoints locations where the probability of discovery is high. Most new oil wells are found directly through the work of geophysicists, but of course they base their analyses in part on geological reconnaissance.

A B.S. degree is essential for a career in geophysics. Only a few colleges offer a B.S. in geophysics, but degrees in physics, geology, mathematics, or some branches of engineering

are also acceptable. On-the-job training usually compensates for the lack of formal classes in geophysics. An M.S. or a Ph.D. is desirable for research positions and also for key jobs on field crews.

High School Emphasis. The physical sciences, mathematics, and English.

College Training. The curriculum taken should be strong in physics, geology, scientific instrumentation, and the computer sciences.

Adult Education. Exploration techniques change rapidly and even established geophysicists have to take occasional courses to keep abreast of developments. Because geophysics is a composite of several disciplines, it is relatively easy to move into the field from physics, geology, etc., through special courses and work experience.

Sources of Information

Society of Exploration Geophysicists, P. O. Box 3098, Tulsa, OK 74101. Booklet: *Careers in Exploration Geophysics.*

American Geophysical Union, 1707 L Street, N.W., Washington, DC 20036. Booklet: *Geophysics, the Earth in Space.*

Lawyer. Energy transcends technology because it is both used and misused by people. In addition, there is not enough of it to go around. Thus the stage is set for conflicts that are usually resolved legally. The adversaries may be individuals, groups, corporations, governments, or organizations. All those involved in courtroom confrontations require the services of lawyers. As the competition for the limited supplies of energy becomes more intense and environmental problems more acute, lawyers will be needed even more.

Legal actions relating to energy matters generally fall into these five categories:

1. Civil law: Litigation, such as damage and breach-of-contract or class action suits.

2. Corporation law: Advising corporations of their legal rights, obligations, and privileges.

3. Tort law: Lawsuits involving wrongs, injuries, and damages not including breach-of-contract.

4. Patent law: Securing patents and protecting the rights of patent owners. (This is particularly important in a rapidly developing technology.)

5. Real estate law: Transfer of properties, including mineral rights.

High School Emphasis. English, history, and social studies.

College Training. Pre-law curricula include English, history, government, philosophy, psychology, and economics.

Adult Education. Law schools with evening courses provide an excellent opportunity for college graduates from almost any field to redirect their careers. The process, however, is long and tedious.

Sources of Information

American Bar Association, 1155 East 60th Street, Chicago, IL 60637. Booklet: *Careers in Law*, 25¢. List of U. S. law schools.

Careers in the Legal Profession, Julian Messner, New York, 1970, $3.95.

Manager. A manager's day-by-day work consists mainly of planning future activities, organizing his personnel and business activities, and measuring the performance of people and machines against established objectives. Much of a manager's time is spent in communication: giving orders, listening to reports of progress and problems, and discussing them with staff, clients, and so on. An important fact, often unappreciated by nonmanagers, is that management is a separate and distinct profession. Professionals in other disciplines often believe they could move easily into a management position only to fail miserably when the chance comes. Management requires education, a talent for leadership, and the ability to get along with a wide variety of people. Regardless of economic conditions, there is always room for more good managers.

Education in management exists at all levels: high school, college, and special business schools. Furthermore, the larger companies generally have their own management training programs. Formal education consists at least of management techniques, economics, law, government, psychology, sociology, labor relations, manufacturing technology, history, English, and computer science. Today, there also exists a strong requirement for advanced degrees such as a Master's Degree in Business Administration.

High School Emphasis. Business, history, English, and mathematics. A high school record of leadership in school activities is very useful to anyone interested in management.

College Training. See last paragraph above for typical courses. Most 2-year colleges offer good basic training in business administration.

Adult Education. In addition to company-sponsored management training, it is fairly easy to find colleges or business schools that offer night or part-time educational opportunities. Many managers began as lawyers, accountants, engineers, or some other kind of specialist. Managers already established in the profession frequently take special courses on new techniques such as the computerization of business.

Sources of Information

American Association of Collegiate Schools of Business, St. Louis, MO 63130. List of business schools.

United Business Schools Association, Washington, DC 20036. *Directory of Business Schools.*

American Management Association, 135 West 50th Street, New York, NY 10020.

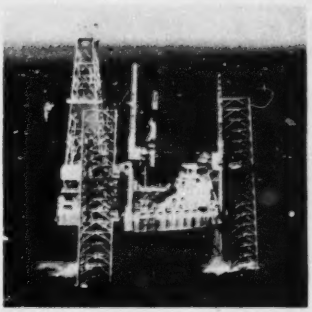
Industrial Management Society, Suite 718, 330 South Wells Street, Chicago, IL 60606.

Marine Engineer/Naval Architect. Marine engineers (or naval architects) design and build structures for the sea, such as ships, piers, and offshore facilities. Aside from oil tankers, the most significant marine structures in the energy field are the offshore platforms supporting oil well equipment plus the accompanying underwater pipelines that carry the oil to shore. A closely allied type of structure is the offshore unloading facility for supertankers that cannot use docks due to size limitations or environmental obstacles. Grander schemes involve floating wind-generator platforms anchored far offshore and floating structures for extracting power from the ocean's vertical thermal difference. Petroleum-handling facilities are now fairly well-developed, but the last two concepts may succeed or fail depending upon the marine engineer's ability to provide safe and long-lasting structures.

High School Emphasis. Mathematics, English, and the physical sciences.

College Training. The regular civil engineering curriculum with additional courses in oceanography, marine biology, and (where available) naval architecture. A few colleges offer special courses of study in marine engineering. Write to the sources listed below for information.

Adult Education. Marine engineering is so specialized that it is virtually impossible to acquire the necessary training without attending one of the few schools with curricula in this field.



Sources of Information

Society of Marine Port Engineers, Room 704, 114 Liberty Street, New York, NY 10006.

Society of Naval Architects and Marine Engineers, 74 Trinity Place, New York, NY 10006.

Mathematician. Energy, the environment, and the interrelation between the two are very complex subjects involving many scientific and engineering variables. Mathematicians are needed to develop mathematical models of everything from the flow of oil through porous rock to electrical power grid behavior. In the area of environmental interactions, engineers need models of atmospheric pollution and the effects of power plant waste heat on river ecology. These are just a few of the problems awaiting mathematicians.

Almost all colleges and universities offer degrees in mathematics. In research and development, the B.S. degree is no longer considered adequate; the Ph.D. is almost essential. Those who do not wish to go this far or who do not have the resources may find the computer scientist's job appealing.

High School Emphasis. Mathematics, statistics, computer usage (where available), English, and the physcial sciences.

College Training. Calculus, statistics, differential equations, number theory, linear algebra, and the theory and applications of computers.

Adult Education. Applied mathematics is such a specialized and demanding field that one cannot easily move into it from other disciplines. The allied field of computer science, however, does not have these difficult hurdles.

Sources of Information

American Mathematical Society, Box 6248, Providence, RI 02904.

Mathematical Association of America, 1225 Connecticut Avenue, N.W., Washington, DC 20036.

Mechanical Engineer. Mechanical engineering, the broadest and most popular branch of engineering, is devoted to the design, building, and production of machines—automobiles, air conditioners, computers—virtually everything considered essential in the modern world. Machines require energy to operate, and mechanical engineers are thus vital in solving the energy crisis. There are three important areas where mechanical engineers can help:

1. The creation of better machines to mine, transport, and process natural fuels.

2. The development of machines that can operate effectively with synthetic fuels.

3. The redesign of contemporary machines so that they consume less energy.

In this abbreviated space, we can only give a single example in each area: (1) Improved automated underground coal-mining machinery is urgently needed. (2) Mechanical engineers must redesign the internal combustion engine so that it runs efficiently on hydrogen-based fuels, but retains as many of the present production facilities as possible. (3) All engines in transportation as well as stationary machinery

should be examined and possibly redesigned for higher efficiencies.

A B.S. is essential, and it is offered by most of the larger colleges and universities. The M.S. is worth obtaining because it leads more quickly into management as well as research and development positions.

High School Emphasis. The physical sciences, mathematics, and English.

College Training. Power engineering, which is concerned with engines, generators, prime movers, etc., is the branch of mechanical engineering most closely associated with the energy problem.

Adult Education. Energy technology moves so fast these days that working mechanical engineers should take night courses or part-time courses in nuclear power, solar power, and environmental engineering.

Sources of Information

Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15086.

American Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30071.

American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

Metallurgist. Our society and our metals are well-adjusted to the properties of coal and oil. It is in working with the newer forms of energy that the metallurgist will find the greatest challenges. Nuclear fuel elements, for example, operate at very high temperatures in the core of a reactor where intense fluxes of nuclear particles rip through metallic structures. If an energy economy based on hydrogen or its derivatives is developed, metallurgists will be called upon to provide pipes and containers and the requisite welding techniques for the new fuels. For example, hydrogen must be stored near absolute zero in a container material that does not allow the tiny hydrogen atoms to escape. Solar power, too, has its material problems centering on the absorption and emission of radiant energy. Batteries, wind vanes, and geothermal power equipment are all in need of solutions for vexing materials problems.

Metallurgy and metallurgical engineering are rather specialized subjects compared with the others discussed in this section. Only about

70 colleges and universities offer a B.S. degree, which is an essential starting point. Even fewer schools offer the advanced degrees needed for research and development, which is where the best jobs are.

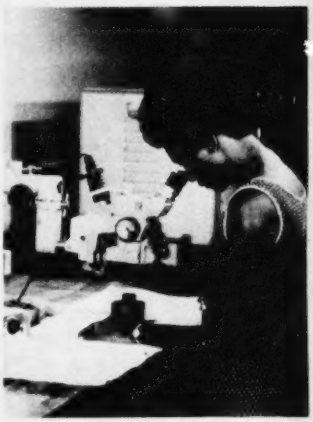
High School Emphasis. The physical sciences, mathematics, and English.

College Training. Metallurgical curricula generally include courses in strength of materials, solid-state physics, optical instrumentation, physical chemistry, and the computer sciences. Such studies can lead into metallurgy if a degree curriculum is not available.

Adult Education. Metallurgy is so specialized and requires so much laboratory training that it is very difficult to educate one's self in metallurgy or transfer into this field from another one.

Sources of Information

American Institute of Mining, Metallurgical, and Petroleum Engineers, 345 East 47th Street, New York, NY 10017. Booklet: *Careers in Metallurgy, Materials Science, and Metallurgical Engineering.*



Mining Engineer. Mining engineers look for minerals and supervise their extraction from the earth. In the search for mineral fuels (oil, coal, uranium), the mining engineer is augmented by the geologist and geophysicist. During the extraction phase, the petroleum engineer and geologist are valuable partners. The target mineral deposits may be located by geophysical instrumentation (seismograph, magnetometer, gravimeter, Geiger counter), by surface and subsurface exploration, or by microwave and infrared surveys from aircraft and satellites. The day of the lone prospector with pick and shovel are obviously gone. Once the desired minerals are found, the mining engineer plans and oversees the construction of mine buildings, tunnels, shafts, and the installation of machinery to recover coal, uranium, and other energy-rich minerals.

An advanced degree is desirable for research positions, but most beginning positions can be obtained with a B.S. from an accredited mining school.

High School Emphasis. The physical sciences, mathematics, and English.

College Training. Curricula in mining engineering include geology, geophysics, construction engineering, metallurgy, petroleum engineering, and economics. The second booklet below lists accredited colleges and universities with programs leading to degrees in mining engineering.

Adult Education. A career change to mining engineering in mid-life is not recommended because of the physical rigors of the job.

Sources of Information

Society of Mining Engineers of AIME, 540 Arapeen Drive, P.O. Box 6800, Salt Lake City, UT 84108. Booklets: *Penetrating New Frontiers with Minerals Engineers* and *Careers for Engineers in the Mineral Industry.*

American Institute of Mining, Metallurgical, and Petroleum Engineers, 345 East 47th Street, New York, NY 10017. Career information.

Nuclear Engineer. About 9% of the total U. S. electric generating capacity comes from the 72 nuclear reactors that are now in operation. By the year 2000 this will increase to 25%. There are about 90 new reactors being built and about 30 on order. Since it takes 10 years to build a reactor, by 1990 the number of new plants coming on line will level off. And so while there will be many new jobs in this field during the next 10 years, unless the present trend changes, there will not be a significant increase in the number of jobs after the early 1990s.

Nuclear engineers work with mechanical engineers, electrical engineers, and other professionals to design, build, and operate nuclear power plants. The nuclear engineer's primary concern is the nuclear reactor, which heats a fluid (usually water) that turns a generator. Reactor design includes the fuel elements, the control systems, the pressure shell, and other containment and safety features. Nuclear engineering requires a knowledge of nuclear physics, heat transfer, strength of materials, electrical engineering, and parts of other disciplines. A nuclear engineer, therefore, is something of an all-round engineer. Other nuclear engineers are involved in the disposal of radioactive wastes.

Many colleges and universities have broadened their curricula to include nuclear engineering. A few offer B.S. degrees in the field. Nuclear engineers or those aspiring to become nuclear engineers have unique opportunities at Government-operated facilities where many part-time educational programs have been established with nearby educational institutions. Nuclear engineering, being a composite discipline, is fairly easy to enter from other scientific and engineering fields.

High School Emphasis. The physical sciences, mathematics, and English.

College Training. A B.S. in nuclear engineering or any one of the many associated engineering fields is essential. Advanced degrees are desirable in research and development work.

Adult Education. On-the-job training and the frequent opportunities for part-time education make it relatively easy to move into nuclear engineering.

Sources of Information

Nuclear Employment Outlook '75, American Nuclear Society, 555 North Kensington Avenue, La Grange, IL 60525, $12.00.

Your Future in Nuclear Energy Fields, W. E. Thompson, Jr., Richards Rosen Press, Inc., New York, 1971, $3.99.

Petroleum Engineer. After geologists and geophysicists have selected a likely spot to drill a well, the petroleum engineer takes over. He selects the drilling equipment and supervises the drilling. Once the well has been brought in, he is responsible for obtaining the maximum profitable recovery of oil and gas. Thus, there is a strong economic facet to this engineering discipline. It is customary to break petroleum engineering into three areas: (1) drilling and well completion; (2) oil production; and (3) reservoir engineering. In addition to the field and office work associated with getting oil and gas out of the ground, most oil companies have well-equipped research laboratories for the purpose of improving field techniques.

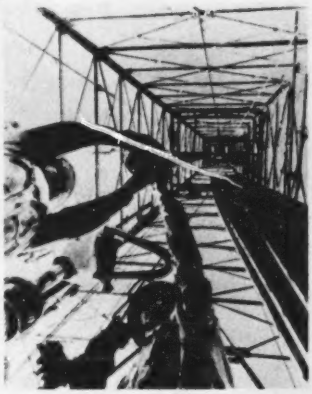
Only a dozen or so schools offer 4-year programs in petroleum engineering, but it is relatively easy to move into the field with degrees in geology, geophysics, or mining engineering. A B.S. is required, and an M.S. or Ph.D. is highly desirable for research and development work. As with most engineering professions, computers are assuming important roles in petroleum engineering — reservoir

engineering, for example – and some proficiency in the computer sciences is a must.

High School Emphasis. The physical sciences, mathematics, and English.

College Training. Courses in geology, mining, chemical engineering, mathematics, computer science, mechanical engineering, and physics can all lead to petroleum engineering, because it is a composite discipline. The strong emphasis on well profitability makes courses in economics and business management very useful in the field.

Adult Education. Like geology and geophysics, petroleum engineering is for young persons, particularly the field jobs. It is, however, fairly easy to become qualified in petroleum engineering by building upon a B.S. in another discipline through night school or part-time college attendance.



Sources of Information

Society of Petroleum Engineers of AIME, 6200 North Central Expressway, Dallas, TX 75206. Booklet: *Careers in Petroleum Engineering.*

American Petroleum Institute, 1801 K Street, N.W., Washington, DC 20006. Pamphlets on career opportunities.

Physicist. Physicists are generalists in the sense that they are trained in electricity, magnetism, sound, the structure of matter, and many other subjects that impinge on the energy problem. The two areas where their talents are most useful are in the search for new fuel sources and in the discovery and development of alternate energy sources. The fuel hunters are the geophysicists and are discussed separately. No such specialization is possible in the hunt for new energy sources because the possibilities seem endless. In solar energy the study of the absorption and reflection of sunlight is a job for the physicist as is research on solar cells. Nuclear power has always been the physicist's domain, particularly the analysis of the reactor itself and radioactivity. Cryogenics (low-temperature physics) is another area of expertise for physicists. This will be important if a low-temperature fuel, such as hydrogen, ever becomes dominant. Meanwhile, cryogenically cooled superconductors are being tested by physicists and electrical engineers for possible power transmission.

Physicists are also involved in searching for ways to harness the deuterium in water, which is the greatest natural source of potential fuel that has been found. The search, in this case, concentrates on techniques of creating a controlled magnetic fusion reaction. Physicists apply magnetic fields to confine gases (plasmas) at temperatures as high as that inside the sun.

Or, they shoot laser beams at tiny fuel targets to ignite fusion reactions in which deuterium nuclei combine and release energy. The trick, so far not attained, is to do this economically on a sustained basis.

Almost all colleges and universities have physics departments and offer at least a B.S. in physics. However, anyone aspiring to a career in physics should plan to get an M.S. also. Physics is an immense field and an additional year or two of study is most useful in obtaining the better jobs. Fully one-third of all physicists now have Ph.D's. which indicates the value of advanced degrees in this demanding field.

High School Emphasis. The physical sciences, mathematics, English, and computer applications.

College Training. Advanced degrees are desirable. For work in the energy field, electives in geology, mechanical engineering, electrical engineering, and computer science will be useful. Some area of specialization should be chosen for M.S. training.

Adult Education. The broad background of the physicist makes it relatively easy for him to change fields through experience or part-time education. Many physicists become in effect electrical engineers, geophysicists, computer scientists, etc.

Sources of Information

American Institute of Physics and American Association of Physics Teachers, 335 East 45th Street, New York, NY 10017.

Urban Planner. Urban planners have a role in the solution of the energy crisis because they must provide for the future growth and revitalization of urban areas. With large changes coming in the way we generate and use energy, the organization of cities (buildings, highways, mass transit, etc.) is bound to be strongly affected. In cooperation with other types of engineers, urban planners must assess the role of transportation in the city in the light of, say, a switch from petroleum-based fuels to a hydrogen economy. The availability of superconducting cables could make it feasible to remove electric power generating plants from cities completely. Again, what would be the effect of converting office building heating plants to coal? Would air quality suffer? How could the immense quantities of coal be delivered without snarling traffic? These are the kinds of questions that the urban planner helps answer.

EPA — Documerica Bob W. Smith

Urban planners often obtain their education in city planning, architecture, or engineering. A B.S. in these fields is often sufficient to qualify one for a position. It is better, however, for the holder of a B.S. to also obtain an M.S.

in urban planning at one of the more than 60 schools that now offer this degree. Much urban planning education consists of analyzing and trying to solve typical city problems. In this sense, urban planning is more of an empirical science than a theoretical one.

High School Emphasis. English, history, social science, and the physical sciences.

College Training. A great variety of courses is useful to a prospective urban planner: psychology, English and other languages common in urban aras, history, architecture, construction engineering, economics, and so on. Summer job experience in a city planners' office is highly recommended.

Adult Education. So many disciplines contribute to urban planning that one may begin almost anywhere to supplement his previous education and experience with night classes and part-time schooling.

Sources of Information

American Institute of Planners, 917 15th Street, N.W., Washington, DC 20005. Career data and list of schools.

American Society of Planning Officials, 1313 East 60th Street, Chicago, IL 60637. Career data and list of schools.

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